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June 12 2007

Janet Rosati
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Superfund Division (SFD-8-2)
US Environmental Protection Agency
Region IX
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San Francisco, CA 94105

Re: Motorola 52nd Street Superfund Site
Arizona Public Service Company
Pinnacle West Capital Corporation
505, 502, 501 South Second Avenue
U.S. EPA Docket No. 2004-25
Technical Memorandum – Regional Groundwater Flow Model

Dear Ms. Rosati:

Arizona Public Service Company and Pinnacle West Capital Corporation (collectively "APS") entered into an Administrative Order on Consent (AOC) with the United States Environmental Protection Agency (EPA). The AOC, which became effective July 29, 2004, requires APS to perform a Focused Remedial Investigation and Feasibility Study (Focused RI/FS) at APS properties located at 501, 502, and 505 South 2nd Avenue in Phoenix, Arizona (the Facility). The purpose of the Focused RI/FS is to determine if the Facility is a source of contaminants of concern (COC) present in groundwater within Operable Unit 3 (OU3) of the Motorola 52nd Street Superfund Site.[1]

In connection with the Focused RI/FS, APS has completed certain investigative activities at the Facility, including an additional soil vapor survey, installation of a soil vapor monitoring well, and the installation of additional groundwater monitoring wells. An important issue of the Focused RI/FS will be to understand

[1] Per Section V. 11. h. of the AOC, "Motorola 52nd Street Superfund Site shall mean Operable Units 1,2,3 of the Motorola 52nd Street Superfund Site, located within the approximate boundaries of 52nd Street to the east, 7th Avenue to the west, McDowell Road to the north and Buckeye Road to the southwest.

past, current and future groundwater flow conditions within OU3. Specifically the influence of past Salt River flooding events and the potential influence of the Salt River flooding on groundwater flow conditions beneath the APS Facility within OU3.

The purpose of this Technical Memorandum is to present data requirements related to developing a regional groundwater flow and advective transport model to accurately simulate historical and predicted future groundwater flow conditions in OU3. This Technical Memorandum describes the approach that will be used or evaluated in a regional groundwater flow model, and will specifically focus on historical data and identify data for the development of the groundwater model.

If you need additional information, please call or email me.
Sincerely,

Judy Heywood

Judy Heywood
Remediation Project Manager

Enclosure (one hardcopy, electronic)

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TECHNICAL MEMORANDUM
Regional Groundwater Flow Model
Motorola 52nd Street Superfund Project, Operable Unit 3
Arizona Public Service Company
EPA Docket No. 2004-25

Submitted to:

Arizona Public Service Company
Phoenix, Arizona

REGISTERED GEOLOGIST
CERTIFICATE NO.
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JAMES M.
OLIVER
Date Signed 6.12.07
ARIZONA U.S.A.

Submitted by:

AMEC Earth and Environmental, Inc.
Tempe, Arizona

AMEC Project No. 7-115-005007
June 11, 2007

EXECUTIVE SUMMARY

Arizona Public Service Company and Pinnacle West Capital Corporation (collectively "APS") has entered into an Administrative Order on Consent (AOC) with the United States Environmental Protection Agency (EPA). The AOC requires APS to perform a Focused Remedial Investigation and Feasibility Study (Focused RI/FS) at certain APS properties located at 501, 502, and 505 South 2nd Avenue, Phoenix, Arizona (Facility). The purpose of the Focused RI/FS is to determine if the APS Facility is a potential contributor of certain contaminants of concern (COCs) that are present in groundwater within Operable Unit 3 (OU3) of the Motorola 52nd Street Superfund Project[1]. An important issue of the Focused RI/FS will be to understand past, current and future groundwater flow conditions within OU3. Specifically the influence of past Salt River flooding events and the potential influence of the Salt River flooding on groundwater flow conditions beneath the APS Facility within OU3.

The purpose of this Technical Memorandum is to present data requirements related to developing a regional groundwater flow and advective transport model to accurately simulate historical and predicted future groundwater flow conditions in OU3. This Technical Memorandum describes the approach that will be used or evaluated in a regional groundwater flow model, and will specifically focus on historical data and identify data for the development of the groundwater model.

[1] Per Section V. 11. h. of the APS AOC, "Motorola 52nd Street Superfund Project shall mean Operable Units 1,2,3 of the Motorola 52nd Street Superfund Site, located within the approximate boundaries of 52nd Street to the east, 7th Avenue to the west, McDowell Road to the north and Buckeye Road to the southwest.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
AWQS	Ambient Water Quality Standards
AMA	Active Management Area
Amsl	above mean sea level
AMEC	AMEC Earth & Environmental, Incorporated
AOC	Administrative Order on Consent
APS	Arizona Public Service Company and Pinnacle West Capital Corporation
ARM	Absolute Residual Mean
Bgs	below ground surface
CA	chloroethane
CFS	Cubic feet per second
cis-1,2-DCE	cis-1,2-dichloroethene
COC	Contaminant of concern
COP	City of Phoenix
CPPM	Central Phoenix Plume Model
CSM	Conceptual Site Model
1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethene
D	Deep hydrostratigraphic zone
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FRA	Focused Risk Assessment
Ft	Feet
Ft/day	Feet per day
Ft/ft	Feet per feet
ft^3	cubic feet
GRDD	Granite Reef Diversion Dam
HASP	Health and Safety Plan
HSU	Hydrostratigraphic unit
L	Liter
LAU	Lower Alluvial Unit
M	First Intermediate Hydrostratigraphic Zone
M2	Second Intermediate Hydrostratigraphic Zone

LIST OF ACRONYMS AND ABBREVIATIONS (Con't)

MAU	Middle Alluvial Unit
MCLs	maximum contaminant levels
mg/Kg	milligrams per kilogram
µg/L	microgram per liter
MGP	manufactured gas plant
mL	Milliliter
mL/min	milliliters per minute
NAD	North American Datum
NOI	Notice of Intent
NPL	National Priorities List
OD	outside diameter
OU1	Operable Unit 1
OU2	Operable Unit 2
OU3	Operable Unit 3
PAHs	Polynuclear Aromatic Hydrocarbons
PCBs	polychlorinated biphenyls
PCE	tetrachloroethene
PCG2	Pre-Conditioned Gradient solver
Ppb	parts per billion
PRGs	preliminary remediation goals
PRP	Potentially Responsible Parties
PQLs	Practical Quantitation Limits
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
R^2	R-squared
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
RL	reporting limit
RPD	relative percent difference
RSD	Residual Standard Deviation
S	Shallow Hydrostratigraphic Zone
SOW	Statement of Work
SRL	Soil Remediation Level
SRV	Salt River Valley
SSR	Sum of Squared Residuals

LIST OF ACRONYMS AND ABBREVIATIONS (Con't)

SVMW	soil vapor monitoring well
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
TCE	Trichloroethene
trans-1,2-DCE	trans-1,2-dichloroethene
UAU	Upper Alluvial Unit
USGS	United States Geological Survey
VOCs	volatile organic compounds
West SRV	West Salt River Valley
WP	Work Plan

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1.0 INTRODUCTION

Arizona Public Service (APS) is submitting this Technical Memorandum on Regional Groundwater Flow Model Parameters as part of the Focused Remedial Investigation and Feasibility Study (Focused RI/FS) currently being conducted at the APS properties located at 501, 502, and 505 South 2nd Avenue, Phoenix, Arizona (Facility) (Figure 1). The Facility is located within the boundaries of Operable Unit 3 (OU3) of the Motorola 52nd Street Superfund Project[2]. The Focused RI/FS is being completed by APS pursuant to the Administrative Order on Consent (AOC) between APS and the United States Environmental Protection Agency (EPA), effective date July 29, 2004 (EPA Docket No. 2004-25). An important issue of the Focused RI/FS will be to understand past, current and future groundwater flow conditions within OU3. Specifically the influence of past Salt River flooding events and the potential influence of the Salt River flooding on groundwater flow conditions beneath the APS Facility.

In order to understand the flow conditions, a groundwater model will be developed to evaluate historical groundwater conditions and to project future conditions. This Technical Memorandum describes the modeling parameters that will be used or evaluated for use in a regional groundwater flow model, and will specifically focus on the following topics:

- Collection of historic surface water and groundwater data,
- Evaluation of sources and amounts of recharge to groundwater,
- Evaluation of historic groundwater production,
- Evaluation of historic flow of the Salt River,
- Evaluation of historic groundwater flow direction and magnitude,
- Evaluation of the impact to groundwater flow direction and magnitude from past flood events,
- Evaluation of historic chemical concentrations in groundwater,
- Evaluation and recommendation for an appropriate model,
- Identification of the general parameters for groundwater modeling,
- Identification of the model calibration targets, and
- Presentation of the general modeling process to be used to evaluate historical groundwater flow conditions.

[2] Per Section V. 11. h. of the APS AOC, "Motorola 52nd Street Superfund Site shall mean Operable Units 1,2,3 of the Motorola 52nd Street Superfund Site, located within the approximate boundaries of 52nd Street to the east, 7th Avenue to the west, McDowell Road to the north and Buckeye Road to the southwest.

1.1 Model Objective

The objective of the work scope will be to develop a regional groundwater flow and advective transport model to accurately simulate historical and predicted future groundwater flow conditions in OU3. The model will be developed within the U.S. Geological Survey MODFLOW 2005 numerical model code (Harbaugh, 2005). The model will be calibrated to represent groundwater flow conditions in the saturated alluvial aquifer and include simulations of selected past surface water events in the Salt River. The model simulations will occur from a time period of 1940 through 2100. Model stress periods and time steps will be appropriately included to accurately calibrate past groundwater stresses (e.g., flooding, groundwater withdrawals). The model is not intended to be used to simulate chemical fate and transport.

The model will be developed and calibrated to the following applicable American Society for Testing and Materials (ASTM) groundwater modeling guidelines (ASTM, 1999):

- Standard Guide for Application of a Groundwater Flow Model to a Site-Specific Problem (ASTM D5447-93)
- Standard Guide for Comparing Groundwater Flow Model Simulations to Site-Specific Information (ASTM D5490-93)
- Standard Guide for Defining Boundary Conditions in Groundwater Flow Modeling (ASTM D5609-94)
- Standard Guide for Defining Initial Conditions in Groundwater Flow Modeling (ASTM D 5610-94)
- Standard Guide for Conducting Sensitivity Analysis for a Groundwater Flow Model Application (ASTM D 5611-94)
- Standard Guide for Documenting a Groundwater Flow Model Application (ASTM D5718-95)
- Standard Guide for Calibrating a Groundwater Flow Model Application (ASTM D5891-96)

2.0 BACKGROUND AND REGIONAL DESCRIPTION

2.1 Geology

OU3 lies within the Basin and Range Physiographic Province in Central Arizona. In this area, mountains generally comprised of crystalline rock separate broad alluvial valleys. Mountains represent upthrown fault blocks from which sediments have been eroded and deposited in basins below. In the centers of these basins, depths to bedrock can exceed 10,000 feet. OU3 is located in the Western Salt River Valley (SRV) Sub-Basin of the Phoenix Active Management Area (AMA), a groundwater basin established by state statute.

Subsurface geology beneath OU3 is typical for the West SRV and for the Phoenix area. In the subsurface, sedimentary units that overlie the bedrock in the area of OU3 are the Upper Alluvial Unit (UAU), the Middle Alluvial Unit (MAU), and the Lower Alluvial Unit (LAU). These units are comprised of alluvial deposits associated with surface fluvial/alluvial deposition processes. The UAU is comprised mostly of unconsolidated gravel, sand, and silt deposited in alluvial channel, terrace, and floodplain deposits (Corell and Corkhill, 1994). The MAU is comprised of unconsolidated to semiconsolidated clay, silt, silty sands, and gravels deposited in playa, alluvial fan, and fluvial environments. The MAU is significantly finer grained than the UAU in most areas. The LAU is subdivided into two parts in the area of the Facility: the lower part consists of evaporite deposits (gypsum and anhydrite) interbedded with sand, gravel, and basaltic rocks. The upper part is comprised of semi-consolidated sand, gravel, and silt.

Based on the Shaw Environmental, Inc. *Final Groundwater Investigation Report, Phase I and II Well Installation*, dated January 2005, groundwater impacted by the COCs within the OU3 Study Area occurs in the unconsolidated UAU deposits (Shaw, 2005). For this work scope and in reference to groundwater monitoring, the UAU has been further subdivided into four hydrostratigraphic zones: Shallow (S), First Intermediate (M), Second Intermediate (M2), and Deep (D). The relationship between the hydrostratigraphic zones is shown in Table 1.

2.2 The Salt River

The Salt River is a tributary of the Gila River originating in eastern Gila County, Arizona. Prior to groundwater development in the Phoenix area, the Salt River was a gaining perennial stream, and flow in the groundwater system generally followed topography from east to west until Roosevelt Dam was engineered on the Salt River in 1912.

The Salt River, a major water resource for the Greater Phoenix Metropolitan area, passes through the valley between the Mazatzal Mountains and Superstition Mountains and supplies several consecutive reservoirs: Lake Roosevelt (formed by Roosevelt Dam), Apache Lake (Horse Mesa Dam), Canyon Lake (Mormon Flat Dam), and Saguaro Lake (Stewart Mountain Dam), forming a continuous chain of lakes almost 60 miles long. Granite Reef Diversion Dam (GRDD) is located approximately 4 miles downstream of the confluence of the Salt and Verde Rivers and about 22 miles east of OU3. Below GRDD, the riverbed of the Salt is typically dry, except during periods of increased precipitation when water releases (flooding) occur in the Salt River through Stewart Mountain Dam from Lake Saguaro.

In 1999, Tempe Town Lake was created by filling a portion of the Salt River riverbed with groundwater in the vicinity of Mill Avenue in Tempe, Arizona. The Tempe Town Lake is a lined basin with inflatable dams and groundwater wells used to capture water that may infiltrate underneath the lake. During flooding events, the dams are deflated to allow passage of Salt River flood waters, and the groundwater pumps are not operated. It is not expected that Tempe Town Lake will be a source of recharge to the model domain.

2.2.1 Historical Record of Flooding

In times of normal precipitation, Salt River flows are retained in the reservoirs and conveyed to the Phoenix area via a series of canals for water supply. During extended precipitation and snow melt events within the Salt River Watershed, the storage capacities of the reservoirs are exceeded and Salt River flows are released downstream of the dams. In Salt River flooding events, water flows over the GRDD resulting in surface water flows in the Salt River channel south of OU3. In recent years, the most notable Salt River flooding events have occurred in 1941, 1973, 1979, 1983, 1985, two in 1992, 1995, and 2005. A record of the precipitation of the Salt River Valley is provided in Figure 2 and the historical record of Salt River flow over GRDD from 1935 to 2005 is depicted in Figure 3.

2.2.2 Interconnection of Surface Water and Groundwater

The primary sources of recharge to groundwater from surface water in OU3 occur in the form of:

- Irrigation canal leakage,
- Deep percolation of excess surface water irrigation,
- Surface water runoff, and
- Flood releases of the Salt River over GRDD.

The most significant of these is the hydraulic connection that exists between the Salt River and groundwater of the UAU (Salt River Gravels). Recharge to groundwater occurs during periods when flow is present in the Salt River adjacent to OU3 through the Salt River Gravels, thus impacting groundwater flow directions near the Salt River. Research related to the impact flooding of the Salt River has on groundwater recharge of the UAU has been limited. The most comprehensive compilation of data comparing this relationship was conducted by CH2M Hill and Hargis and Associates for Honeywell in 2005 in the Final FRI (CH2MHill and Hargis, 2005).

Regional groundwater data are limited prior to the 1992/1993 high precipitation events. Due to data availability of water levels in the UAU, the relationship between surface water and groundwater will based on observed groundwater flow conditions from the 1995 and 2005 Salt River flooding events. Additional data from SRP and ADWR from events before 1995 will be evaluated and used if available.

2.2.3 Historical Groundwater Fluxes and Magnitude

Historical discharge of the Salt River in the Phoenix area, measured from stream gauging stations, was compared to releases of water over GRDD as part of the Honeywell OU2 project. Data analysis related to the Honeywell facilities indicated that a good correlation exists between groundwater levels and Salt River flow when releases over GRDD exceed 800 cubic feet per second (CFS) (CH2M Hill and Hargis and Associates, 2005). Above 800 CFS, the normal flow channel for the Salt River is saturated in the vicinity of OU3 and the groundwater recharge potential is maximized. For events less than 800 CFS, a less significant correlation can be assessed as the river course is not fully saturated, and the recharge potential is more variable. As expressed by Arizona Department of Environmental Quality (ADEQ 2005) in their comments to Honeywell on their draft FRI, the time the river course is saturated in the Salt River and the duration of a river flow flood event has more influence than the magnitude of the flooding event (CH2M Hill and Hargis and Associates, 2005). Between 1912 and 2006, 105 flood events with flows over 800 CFS occurred. Of these, nine flood events with flows greater than 800 CFS occurred over a period greater than 30 days. A summary of these events is presented in Table 2 and all Salt River flow data is provided in Appendix A.

Recharge from the Salt River high flow, long-duration-flood events causes temporary changes in groundwater flow direction in the alluvial aquifer. The changes are expected to occur along the entire portion of the Salt River that is saturated and the magnitude of the water level impact will diminish with increasing distance from the Salt River. According to CH2M Hill and Hargis and Associates (2005), groundwater flow directions in the Salt River Gravels responded to recharge from flooding events in 1992 and 1995 by rotating toward the west-northwest at maximum azimuths of 302 and 272 degrees for the 1992 and 1995 events, respectively (assuming 0/360 degrees is north, 90 degrees is east, 180 degrees is south, and 270 degrees is west). Non-flood groundwater flow azimuths typically range from 220 to 270 degrees reflecting a west-southwest direction of groundwater flow (CH2M Hill and Hargis and Associates, 2005). Groundwater flow azimuths are illustrated in Figures 4 and 5.

2.2.3.1 Evaluation of Historical Groundwater Production

Groundwater production in the Phoenix area began around 1900. Prior to development in Phoenix, the hydrologic system was in equilibrium. In this steady-state flow condition, groundwater flow is estimated to have been horizontal with minimal vertical movement between major hydrostratigraphic units (Corell and Corkhill, 1994). The Central Phoenix Plume Model (CPPM) reproduced data from Lee (1905) reflecting overall equilibrium conditions, with localized effects from early pumping and drought (Weston, 2000). Data from the CPPM indicate groundwater has flowed predominantly to the west for the past 30 years (Weston, 2000). Historical water level maps from 1900, 1972, 1982 and 1991 are presented in Appendix B.

The contemporary hydrologic flow system in the SRV is dominated by regional pumping, agriculture, canals, flood events, and evapotranspiration. The volume of groundwater in storage in the SRV is estimated to have decreased by approximately 23 million acre-feet since 1900 (Corell and Corkhill, 1994). Water levels in the UAU have decreased substantially, and have been dewatered in some areas. Groundwater depressions are present in regional pumping centers in areas of East Mesa-Gilbert/Queen Creek-Chandler (East) and Deer Valley/Goodyear-Litchfield Park (West). These areas of groundwater development have caused a groundwater divide to form in the East Phoenix/Tempe area, which is influenced by shallow bedrock that is found in this region. The rates and spatial distribution of groundwater pumping has varied throughout the SRV. Over the past 40 years, there has been a general transition in land use from irrigated agriculture to urban development. In conjunction with this change in land use, groundwater pumping patterns within the SRV have changed. Data on past groundwater pumping in the vicinity of OU3 is available in the CPPM (Weston, 2000), ADWR records, and SRP files. Hydrographs for select wells representing general stress periods in the basin are included in Appendix C. Recent maps of the potentiometric surfaces of the Shallow, Intermediate, and Deep Zones (Shaw, 2006) indicate that groundwater flows generally west-southwest in all three zones (Appendix D).

2.2.3.2 Historical Stress Periods

As discussed earlier, groundwater flow in the basin is impacted by regional pumping and high magnitude recharge events from the Salt River. These major events have historically stressed the regional aquifer and impacted the direction of groundwater flow. Eight (8) of the nine (9) flood events occurring over 30 days when flow in the Salt River was greater than 800 CFS, listed in Section 2.2.1, have been identified as major stress periods. Groundwater elevations in the UAU from the following time periods will be used as Salt River flooding event calibration targets:

- March 1973,
- March 1979,
- February 1983,
- February 1985,
- February and December 1992,
- February 1995, and
- January 2005.

These historical groundwater levels are provided in Figures 6 through 13, and the representative historical data are provided in Appendix B.

2.2.3.3 Regional Plume

The Motorola 52nd Street Superfund Project was added to the National Priorities List (NPL) in 1989. The current Superfund Project boundaries encompass an area from 52nd Street on the east to 7th Avenue on the west, and from McDowell Road on the north to Buckeye Road on the south (Figure 14). Historical spills or releases of commercial and industrial solvents, including tetrachloroethene (PCE), trichloroethene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA), have resulted in an extensive plume of contaminated groundwater emanating from these facilities to more than seven miles to the west.

The Motorola 52nd Street Superfund Study Area is divided into three Operable Units. The first operable unit (OU1) was selected to address the sources of soil and groundwater contamination at the Motorola 52nd Street facility, and also to contain contaminated groundwater off-site at 44th Street. The second operable unit (OU2) includes an interim hydraulic control remedy to contain groundwater contamination at 20th Street. The OU2 groundwater treatment system is comprised of three UAU groundwater extraction wells to ideally prevent groundwater from entering OU3. OU3 is located between 20th Street and 7th Avenue and extends from McDowell Road on the north to Buckeye Road on the south. The western boundary of OU3 shifts northward at 3rd Avenue to Buchanan Street, where it extends west from 3rd Avenue to 7th Avenue. The OU3 COCs, established by EPA, are listed in Table 3.

As confirmation of regional groundwater flow conditions, groundwater quality data were obtained through ADEQ databases and compiled to spatially analyze the distribution of PCE and TCE in the UAU within OU3. Of the data compiled, the most complete data sets for the selected COCs represent the following time periods:

- February and November 1994,
- December 1995,
- April and October 1996,
- April 1997,
- March and September 2003, and
- March and September 2005.

PCE and TCE concentrations in groundwater within OU3 are illustrated in Figures 15 through 24, and in Figures 25 through 34, respectively.

3.0 NUMERICAL GROUNDWATER MODEL DESCRIPTION

Information from the OU3, geology, and groundwater flow will be used to design the numerical groundwater model, including the model domain orientation and extent, boundary conditions, discretization, hydrostratigraphic units, and input parameters. Simplifying assumptions may be used to define the model domain and boundary conditions. The model parameters, boundaries and calibration targets are preliminary based on the current understanding of the existing hydrogeologic regime and may be subject to modification during the model construction. The CPMM (Weston, 2000) will be primary reference for information related to well information, pumping records and aquifer testing. Data obtained from the CPMM will be evaluated for accuracy by comparison to ADWR records and SRP files.

3.1 Model Domain Extent and Orientation

The domain of the numerical groundwater model will at a minimum include all of OU3, areas west of OU3, the historical floodplain of the Salt River, and the current channel of the Salt River. The numerical groundwater model will be oriented to approximately 10 degrees to the southwest, with the upgradient and downgradient faces of model grid cells approximately perpendicular to the longitudinal vector of groundwater flow to facilitate the numerical simulation of groundwater flow during non-flood conditions. The proposed orientation and grid boundary of the numerical groundwater model is provided on Figure 35.

3.2 Model Boundaries

The estimated numerical groundwater model boundaries will be selected to represent surface water features, hydrologic conditions, natural groundwater elevation conditions, and topographic conditions in OU3. The boundary conditions will use simplifying assumptions to simulate groundwater hydraulic conditions at the edges of the model area. Four types of boundary conditions, shown on Figure 36, will be used at the edges of the numerical groundwater model: no flow, constant head flux boundaries, general head flux boundaries, and stream cells.

The northwestern and southeastern edges of the model will be no flow boundaries, oriented parallel to the regional groundwater flow direction. The no flow boundaries will be appropriately distant from areas of the numerical groundwater model where current groundwater pumping and groundwater constituent transport are simulated so model boundaries will not significantly affect simulation results. If evaluation of regional pumping shows that past groundwater withdrawals outside of the model domain significantly influenced groundwater flow patterns, portions of these flow boundaries may be modified to accurately simulate the observed groundwater flow conditions.

The downgradient boundary of the numerical groundwater model will be simulated as a constant head boundary, approximating the gradient of regional groundwater levels to the west of OU3. Water levels measured in 1989 will be used to estimate input constant head values for this boundary based on data presented in the CPPM (Weston, 2000). The Salt River will be represented in the model using stream cells at the southeastern model boundary. Data for the Salt River at 24th Street and 51st Street from the U.S. Geological Survey will be set at stage elevations of 1100.88 feet amsl and 1055.58 feet amsl, respectively.

The upgradient edge of the numerical groundwater model will be a general head boundary parallel to the Papago Buttes, where the bedrock is outcropped in East Phoenix. Groundwater elevation measurements at monitoring wells adjacent to the Papago Buttes indicate groundwater elevations at the southeastern edge of the model are higher than groundwater elevations at the northwestern edge of the model. The groundwater in these general head cells may be assigned elevations to represent groundwater elevations similar to measured groundwater elevations at monitoring wells adjacent to the OU2 hydraulic containment system.

3.3 Hydrostratigraphic (HSU) Units

For the purposes of the numerical groundwater model, four HSUs will be used to represent hydrogeologically unique units in the study area as defined by lithology, permeability, direction of groundwater flow, magnitude of hydraulic gradients, and hydraulic conductivity. The HSUs defined for the numerical groundwater model include the UAU, MAU, LAU, and the bedrock. It is not expected that COCs from OU3 sources are present in the MAU or LAU. However, pumping stresses include wells screened in the MAU and LAU, and it will be important to include these units to accurately represent groundwater withdrawals. Currently, it is not anticipated that the UAU will need to be further subdivided into Shallow, M1, M2 and Deep zones. However, if significant vertical flow components are assessed within the UAU, this unit will be subdivided to include additional model layers to represent the UAU.

The hydraulic properties for each hydrostratigraphic unit may be estimated using the range of values provided in the CPPM (Weston, 2000) and are summarized in Table 4 and Figure 37. A discussion of the discrete HSUs is provided in the following sections.

- **HSU A**
  HSU A, otherwise referred to as the UAU, is comprised of gravel, sand, and silt and follows the former course of the Salt River. This unit, once a primary water source, has been dewatered from overproduction in some areas of the Salt River Valley. Hydraulic conductivity ranges from 20 to 250 feet per day (ft/day) and specific yield ranges from 8 to 22 percent, with the largest values near the Salt River (Weston, 2000). Depending on

the evaluation of vertical flow components within UAU of OU3, this unit may be further subdivided between the Shallow, M1, M2 and Deep zones.

- **HSU B**
  A common source of potable groundwater in the region is HSU B, also referred to as the MAU. This unit is comprised of interbedded clay, silt, sand and gravel layers. Hydraulic conductivity ranges from 5 to 50 ft/day, and specific yield of HSU B ranges from 3 to 14 percent (Weston, 2000).
- **HSU D**
  HSU D represents the LAU, which is a conglomerate and gravel unit. A higher potential yield for water sources within the HSU D is located within the upper 500 feet; however, due to the depth to the aquifer, few wells in this unit contribute to potable water supply in the central Phoenix region (Weston, 2000). Hydraulic conductivity in HSU D ranges from 5 to 50 ft/day and specific yield may range from 3 to 15 percent (Weston, 2000).
- **Bedrock**
  Bedrock in the region is crystalline in nature and for purposes of the model, relatively impermeable. This assumption will allow for the top of the bedrock to the base of the model.

3.4 Model Discretization

The numerical groundwater model will use three layers to simulate the important hydrostratigraphic units of the Salt River Valley. Layer 1 will represent the HSU A; Layer 2 will represent HSU B; and Layer 3 will represent HSU D. Additional model layers may be added to further separate the UAU.

The origin of the numerical groundwater model grid will be in the Arizona State Plane North American Datum (NAD) 1983 coordinates (630761.0683 easting feet, 872384.0605 northing feet, 1063.67 elevation feet amsl) with a 10 degree angle of rotation south of west. The proposed width of the numerical groundwater model grid, including active and inactive cells, would be 40,000 feet along the longitudinal axis (i.e., the axis parallel to the direction of groundwater flow), 24,000 feet along the latitudinal axis (i.e., the axis perpendicular to the direction of groundwater flow), and approximately 500 feet along the elevation axis. The model will use a uniform grid of cells 250 feet by 250 feet and contain 96 active rows and 160 active columns. The model grid may be enlarged or refunded if evaluation of historical groundwater flow patterns necessitates an expanded or more detailed model grid.

3.5 Initial Model Input

Initial parameters defined in the numerical groundwater model will be hydraulic conductivity; porosity; recharge; and the stage, bottom elevation, sediment thickness, and sediment conductance of the Salt River. The final numerical groundwater model input parameters will be based on the model calibration process.

3.5.1 Hydraulic Conductivity

Hydraulic conductivity values established in the CPPM (Weston, 2000) will be used to establish range values for the modeled hydrostratigraphic units. Due to the heterogeneous character of the valley gravel deposits, distributed zones of hydraulic conductivities will be applied to the varying model layers. Of these zones, five ranging from 50 to 400 ft/day would represent the horizontal hydraulic conductivity of the HSU A, three would be distributed within HSU B, and two would be used to simulate HSU D. Vertical hydraulic conductivity would also be varied within the units to represent the potential for groundwater to migrate vertically from one unit to another. As no site data are available for vertical hydraulic conductivity in the region, vertical hydraulic conductivity will be assumed at one-tenth the value of horizontal hydraulic conductivity, as applied in the CPPM (Weston, 2000).

3.5.2 Porosity

Porosities will be estimated for each hydrostratigraphic unit in the numerical groundwater model from the common porosity information utilized in the CPPM (Weston, 2000). Porosity values may be modified based on site-specific quantification of effective porosity collected at properties within the model domain.

3.6 Water Balance

Water sources and sinks of the aquifer system that impact the pattern of groundwater flow will be described in a conceptual water budget. The evaluation of the sources of recharge and discharge to the aquifer system will include the rates and temporal variability of the sources.

3.6.1 Recharge

The majority of groundwater recharge in the region originates in the east at the topographic highs, and along the Salt River. Additional sources of recharge in the model area occur in the form of the infiltration of excess irrigation water, leakage from irrigation canals, effluent discharge to river channels, and precipitation infiltration from flooding along drainage channels (Weston, 2000). Preliminary model recharge values used to represent municipal and agricultural recharge range from 5 to 7 percent across the model domain. If evaluation of Tempe Town Lake water-level elevations since 1999 shows a recharge to the UAU, this will be included in the model. The Rio Salado Recharge Project is east of the model domain and will be included as a groundwater flux condition in groundwater flow conditions outside of the model boundaries.

3.6.2 Salt River

The MODFLOW Stream Package would be used to simulate interaction between groundwater and surface water at the Salt River. The CPPM (Weston, 2000) would be used as a baseline for the Stream Package input values. Model simulation results will simulate surface water flows in the Salt River during periods of Salt River flooding. Flows from GRDD will be used as initial flow conditions for the flood simulations.

3.6.3 Canal Leakage

Five major canals are located within the proposed model region: Grand Canal, Roosevelt Canal, Western Canal, North Branch of the Highline Canal, and Arizona Canal. Infiltration rates established by SRP and the Bureau of Reclamation, used in the CPPM (Weston, 2000), will be used in the model.

3.6.4 Discharge

Groundwater discharge in the region occurs primarily in the form of groundwater pumping and evapotranspiration. Groundwater pumping in the model area is divided among agricultural and municipal usage. Pumping and evapotranspiration input values may be incorporated from the CPPM (Weston, 2000). Future municipal groundwater pumping will be based on long-range water management plans that have been prepared by the individual municipalities (i.e., City of Phoenix, City of Tempe, and City of Glendale). In addition, the extraction from the OU2 hydraulic containment system will be included in the model simulation.

3.6.5 Stress Periods and Time Steps

Model stress periods will be selected to correlate with significant changes in groundwater withdrawals and Salt River flooding events. Transient simulations will start in 1940 and end in 2100. A minimum of five (5) time steps will be utilized for each stress period.

3.6.6 Groundwater Flow Path Delineation with Particle Tracking

The USGS particle tracking code MODPATH Version 4.2 will be used to measure the simulated transient advective movement of a mathematical “particle” through the velocity field computed by the numerical groundwater model. Particles will be released from the APS Facility to evaluate the potential movement of groundwater beneath the Facility (including during past Salt River flooding events). Sensitivity analysis will be performed on number of particles released from the APS Facility to prevent bias error caused by limited particles.

4.0 NUMERICAL GROUNDWATER MODEL CALIBRATION

The calibration of the numerical model will be primarily conducted by comparing measured groundwater elevation and groundwater flux with simulated groundwater elevation and groundwater flux. The model calibration process will be conducted to guide changes in model hydraulic parameters necessary to reduce the differences between measured and simulated groundwater elevation; and measured and simulated groundwater flux. The numerical model must be able to simulate wet and dry season conditions without changing the hydraulic conductivity of hydrostratigraphic units.

Initial calibration will be performed on pre-groundwater production steady-state groundwater flow conditions. This initial calibration will be used to estimate boundary fluxes. Final model calibration will be completed by comparing transient flow conditions to: (1) simulated groundwater elevations to observed groundwater elevations from select groundwater monitoring events; and (2) simulated groundwater fluxes at the Salt River to observe groundwater fluxes at the Salt River during a flow event.

4.1 Quantitative Calibration

Quantitative calibration techniques will be used to ensure that the following: the solution of the numerical groundwater model is mathematically accurate; the difference between the groundwater fluxes simulated by the numerical groundwater model and the groundwater fluxes measured during groundwater monitoring events are within an acceptable range; differences between simulated groundwater elevations and measured groundwater elevations are randomly distributed (i.e., unbiased); variation in simulated groundwater elevation is due to variation in observed groundwater elevation; and the groundwater elevations simulated by the numerical groundwater model are not overly sensitive to changes in numerical groundwater model input. The quantitative techniques that will be used to calibrate the numerical groundwater model are:

- Satisfaction of global mass balance (i.e., simulated groundwater flux into the model domain must equal simulated groundwater flux out of the model domain),
- Comparison of groundwater fluxes in the Salt River simulated by the numerical groundwater model to vertical groundwater fluxes measured at the Salt River as documented,
- Comparison of groundwater elevations simulated by the numerical groundwater model and groundwater elevations measured during groundwater monitoring events with the 95 percent confidence interval,

- Least squares regression analysis of plots of groundwater elevation simulated by the numerical groundwater model versus groundwater elevation measured during a groundwater monitoring event, and
- A sensitivity analysis of groundwater elevation simulated by the numerical groundwater model to hydraulic conductivities and recharge.

4.1.1 Local Targets for Measurements of Groundwater Elevation

Regional groundwater elevation data and site specific APS groundwater elevation measurements will be used to evaluate model accuracy. Calibration targets will be used within the model domain to evaluate specific differences between model simulated and observed water-level elevations. Calibration targets will be selected to represent both spatial and temporal variability. As an initial calibration target data set, the 156 well locations used in the CPPM (Weston, 2000) will be evaluated. This data set will be expanded to include water-level elevation maps that have been recently prepared for the Motorola 52nd Street Superfund Study Area.

4.1.2 Global Mass Balance

The MODFLOW 2005 solver package will be used for the model. The Preconditioned Conjugate Gradient solver (PCG) iteratively calculates a transient solution for the numerical groundwater model by minimizing the differences between the mass of groundwater entering a model cell and the mass of groundwater leaving a model cell. The global mass balance is calculated by MODFLOW and included in the list file. The percentage difference between mass in and mass out for the selected simulation calibration will be analyzed in relation to the total mass. The global mass balance difference will be less than 5 percent in the calibrated model. The head difference tolerance for the solver will be set at less than 0.01 feet in the final simulations.

4.1.3 Least Squares Regression Analysis

The measured groundwater elevations would be compared to simulated groundwater elevations by linear regression to determine the correlation between simulated and measured groundwater elevations. A comparison of simulated versus measured groundwater elevations for all calibration points and for calibration points in each layer will be provided for select groundwater simulation timeframes. The least squares regression analysis will be used to indicate model calibrated, as supported by:

- The linearity of plotted simulated versus measured groundwater elevation points, and

- The r-squared (r^2) value of the simulated versus measured groundwater elevation plot, where r^2 is a statistical measure of the degree of accuracy to which modeled values represent measured data points.

4.1.4 Comparison of Residual to 95 percent Confidence Interval

The difference between simulated and measured groundwater elevation at each calibration point, the residual, would be calculated for each of the calibration scenarios. The 95 percent confidence interval at each calibration point would be estimated using the standard deviations associated with seasonal variations in groundwater elevations (seasonal lows generally occur in September and seasonal highs usually occur in March). At each calibration point, the residual would be compared to the value of the 95 percent confidence interval estimated for the calibration point.

Because 95 percent confidence intervals are estimated from standard deviations of groundwater elevations, they do not allow for numerical errors (e.g., discretization error) and they are biased by a small sample size. Ninety-five percent confidence intervals would be used to identify areas of the numerical model that systematically overestimated or underestimated measured groundwater elevation and the extent to which calibration could be used to more evenly distribute the error. A spatially random distribution of overestimation and underestimation of measured groundwater elevations suggests that a numerical groundwater model is well calibrated.

4.1.5 Sensitivity Analysis

A sensitivity analysis would be conducted to determine the accuracy of the model. Sensitivity analysis involves changing numerical groundwater model input and observing the effect on the quality of the numerical groundwater model calibration to assess the stability of the numerical groundwater model. The Residual Standard Deviation (RSD), Absolute Residual Mean (ARM), and Sum of Squared Residuals (SSR) quantify the difference between simulated groundwater elevations and observed groundwater elevations. The model will be calibrated to a SSR close to less than 0.1, an ARM less than 5 percent and a RSD less than 15 percent.

4.2 Qualitative Calibration

Qualitative calibration techniques ensure that the direction of groundwater flow simulated by the numerical groundwater model is approximately the same as the direction of groundwater flow estimated from groundwater monitoring events, and differences between simulated and measured groundwater elevations are evenly distributed spatially. The qualitative techniques that would be used to calibrate the numerical groundwater model are:

- Comparison of measured groundwater elevation contours with simulated groundwater elevation contours by overlaying them on a common base map,
- Comparison of differences between simulated and measured groundwater elevations along the flow path, and
- Comparison of simulated groundwater flow path defined by particle tracking with expected groundwater flow path defined by solute concentrations measured during groundwater monitoring events.

4.2.1 Spatial Groundwater Elevation Comparison

Groundwater elevation contours developed from simulated groundwater model calibrations and from measured groundwater elevations will be compared. Comparing the pattern of simulated groundwater elevation contours to measured groundwater elevation contours may reveal patterns in the residual, which can be used to calibrate a model. Comparisons of measured and simulated groundwater elevation contours would be conducted for the HSU A, HSU B, and HSU D.

4.2.2 Groundwater Elevations along the Groundwater Flow Path

The simulated and measured groundwater elevations will be compared at calibration points along the groundwater flow path and perpendicular to the groundwater flow path, with cross section locations to be identified. The plots of simulated and measured groundwater elevations would provide a reference to determine if simulated and measured groundwater gradients are similar along and perpendicular to the groundwater flow path. In addition, the 95 percent confidence interval would be provided for each calibration point, indicating error.

5.0 REPORTING

The model report will document the preparation, calibration and result of the model simulations. The report will include written text, tabular summaries and graphical figures as appropriate. The report will be included as an appendix to the FRI report. As per the ASTM guidance (ASTM D5447-93), the report will be prepared according to the following outline:

- Introduction
  - General Setting
  - Study Objectives
- Conceptual Model
  - Aquifer System Framework
  - Groundwater Flow System
  - Hydrologic Boundaries
  - Hydraulic Properties
  - Sources and Sinks
  - Water Budget
- Computer Code
  - Code Selection
  - Code Description
- Groundwater Flow Model Construction
  - Model Grid
  - Hydraulic Parameters
  - Boundary Conditions
  - Selection of Calibration Targets
- Calibration
  - Residual Analysis
  - Sensitivity Analysis
  - Model Variation
- Predictive Simulations
- Summary and Conclusions
  - Model Assumptions and Limitations
  - Model Predictions
  - Recommendations
- References
  - Appendices for Model Input Files

6.0 REFERENCES

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Table 1
Hydrostratigraphic Column Description

Aquifer Unit	Aquifer Subunit	Hydrostratigraphic Zone	Description
Upper Alluvial Unit	Salt River Gravels	Shallow Zone (S)	Coarse-grained Salt River Gravels, including minor amounts of interbedded and laterally discontinuous fine-grained deposits. The Shallow Zone begins at the water table, approximately 90 feet bgs, and its base ranges in depth from 100-115 feet bgs. The Zone is the upper portion of the thick sequence of predominately coarse gravel and cobbles with varying amounts of sand, silt, and clay in the matrix, and occasional interbedded sands and silts.
	Basin Fill	First Intermediate Zone (M)	Interbedded coarse and fine-grained deposits dominated by gravel similar to the Salt River Gravels. The Zone ranges in thickness from 55 to 85 feet. An interval of finer sediments composed of variously interbedded sand, silt, and clay forms the base of the First Intermediate Zone. The base is present at depths between 170 and 190 feet bgs. This finer grained interval is found at shallower depths in the eastern portion of OU3 and ranges in thickness between 5 and 20 feet.
		Second Intermediate Zone (M2)	Interbedded coarse and fine-grained deposits dominated by gravel similar to the Salt River Gravels. The Second Intermediate Zone lies between approximately 195 and 230 feet bgs. Generally, the Zone is composed of coarse gravel and cobbles with varying amounts of sand and fines in the matrix, and beds of medium to coarse sand with varying amounts of fines.
		Deep Zone (D)	Upper fine-grained layer with an underlying interval of interbedded fines and sand. The Deep Zone is a sequence of sediments that are much finer grained than those within the Shallow and Intermediate Zones. Within most of the OU3 cores these sediments are a massive accumulation of brown silty clay and clayey silt with locally discontinuous sand lenses and no evidence of internal bedding. Sand lenses are between 5 and 30 feet thick. This unit likely corresponds to the MAU described by Corell and Corkhill (1994).

TABLE 2
Salt River Flood Events over Granite Reef Dam above 800 CFS

Event No.	Event Date	Flow above 800 CFS Days		Event No.	Event Date	Flow above 800 CFS Days		Event No.	Event Date	Flow above 800 CFS Days
1	Dec-1959	2		30	May-1979	2		58	Mar-1991	10
2	Aug-1964	1		31	Jan-1980	11		59	Apr-1991	2
3	Apr-1965	4		32	Feb-1980	21		60	Dec-1991	2
4	Dec-1965	6		33	Mar-1980	20		61	Jan-1992	25
5	Dec-1965	13		34	Apr-1980	5		62	Feb-1992	76
6	Feb-1966	12		35	May-1980	5		63	May-1992	2
7	Sep-1966	1		36	Mar-1982	6		64	May-1992	6
8	Dec-1967	2		37	Mar-1982	1		65	May-1992	4
9	Feb-1968	6		38	Dec-1982	7		66	Aug-1992	7
10	Feb-1968	6		39	Dec-1982	13		67	Aug-1992	5
11	Mar-1968	5		40	Feb-1983	42		68	Dec-1992	107
12	Apr-1968	8		41	Mar-1983	23		69	Apr-1993	2
13	Sep-1970	3		42	Apr-1983	21		70	Apr-1993	9
14	Oct-1972	1		43	May-1983	3		71	May-1993	11
15	Oct-1972	3		44	Oct-1983	22		72	May-1993	5
16	Dec-1972	2		45	Dec-1983	16		73	Jan-1995	5
17	Dec-1972	4		46	Jan-1984	2		74	Jan-1995	3
18	Jan-1973	3		47	Dec-1984	15		75	Feb-1995	42
19	Feb-1973	6		48	Jan-1985	18		76	Apr-1995	7
20	Mar-1973	5		49	Jan-1985	19		77	Mar-1998	8
21	Mar-1973	44		50	Feb-1985	51		78	Apr-1998	6
22	Apr-1973	24		51	Apr-1985	2		79	Jan-2005	35
23	May-1973	2		52	Apr-1985	8		80	Feb-2005	23
24	Mar-1978	7		53	Dec-1985	21		81	Mar-2005	5
25	Mar-1978	11		54	Apr-1986	1		82	Mar-2005	2
26	Mar-1978	1		55	Mar-1987	8		83	Mar-2005	1
27	Dec-1978	21		56	Apr-1988	3		84	Mar-2005	3
28	Jan-1979	30		57	Mar-1991	3		85	Mar-2005	1
29	Mar-1979	36								

Notes:
CFS Cubic Feet Per Second

Table 3
OU3 Contaminants of Concern (COCs)

Site Characterization Screening Levels and Remedial Action Levels

Chemical Name	Air (µg/m^3)			Soil (mg/kg)				Soil Gas (µg/m^3)	Groundwater (µg/L)			
	Direct Contact Exposure Pathways					Migration to Groundwater		Migration to Indoor Air (Vapor Intrusion)	Direct Contact Exposure Pathway		2002 Max. Detections	
	Annual 30 yr.	Annual 70 yr.-24 Hour		Residential - Non Res.					EPA PRG (Tap Water)	EPA MCL/ ADEQ AWQS		
	EPA PRG	ADHS AAQGs Annual-24 Hour	ADHS HBGLs	EPA PRGs	ADEQ SRLs	EPA SSLs DAF 1-20	ADEQ GPLs	EPA SSLs AF 0.1			OU2 Area	OU3 Area
Chloroethane/Ethyl Chloride (CA)	2.3	N/A	4300-43000	3.0 - 6.5	1100-4200	N/A	N/A	100000	4.6	N/A	**160**	**NS**
1,1-Dichloroethane (1,1-DCA)	520	N/A-3200	210-2100	510-1700	500-1700	1-23	N/A	5000	810	N/A	110	50
1,2-Dichloroethane (1,2-DCA)	0.074	0.038-14	0.73-43	0.28 - 0.60	2.5-5.5	0.001-0.02	0.21	0.94	0.12	5	ND	0.6
1,1-Dichloroethylene (1,1-DCE)	210	N/A-63	0.38-140	120 - 410	0.36-0.8	0.003-0.06	0.81	2000	340	7	**130**	**60**
cis-1,2-Dichloroethylene (cis-1,2-DCE)	37	N/A-6300	15-150	43-150	31-100	0.02-0.4	4.9	N/A	61	70	**220**	**150**
trans-1,2-Dichloroethylene (trans-1,2-DCE)	73		30-300	69-230	78-270	0.03-0.7	8.4	N/A	120	100	1.4	3
Tetrachloroethylene (PCE)	0.32	1.7-640	15-150	0.48-1.3	53-170	0.003-0.06	1.3	8.1	0.1	5	**15**	**19**
1,1,1-Trichloroethane (1,1,1-TCA)	2300	N/A-15000	430-4300	1200	1200-4800	0.1-2	1.0	22000	3200	200	2.4	ND
1,1,2-Trichloroethane (1,1,2-TCA)	0.12	0.062-23	1.2-60	0.73-1.6	6.5-15	0.0009-0.02	N/A	1.5	0.2	5	ND	ND
Trichloroethene (TCE)	0.017	0.58-210	9-90	0.053-0.11	27-70	0.003 - 0.06	0.61	22	0.028	5	**650**	**720**
Vinyl Chloride/Chloroethene (CE)	0.11	0.012-4.3	0.02-N/A	0.079-0.75	0.016-0.035	0.0007-0.01	N/A	2.8	0.02	2	**16**	0.3
1,4-Dioxane	0.61	N/A-710	6-N/A	44-160	400-1700	N/A	N/A	N/A	6.1	N/A	**11**	**12**

EPA = EPA Region 9
AAQGs = Ambient Air Quality Guidelines
SSLs = Soil Screening Levels
AF = Soil Gas to Indoor Air Attenuation Factor
AWQS = AAC Aquifer Quality Standards
OU = Operable Unit
MCL = National Primary Drinking Water Standards Maximum Contaminant Level
ADEQ = Arizona Department of Environmental Quality
PRG = Preliminary Remediation Goal (October 2004)(www.epa.gov/region9/waste/sfund/prg/files /04prgtable.pdf)
GPLs = Groundwater Protection Levels
N/A = Not Available
NS = Not Sampled
SRLs = Soil Remediation Levels, Arizona Administrative Code (AAC) Title 18, Ch. 7 Appendix A
ADHS = Arizona Department of Health Services
DAF = Dilution Attenuation Factor
ND = Non Detect
HBGLs = Health-Based Guidance Levels

TABLE 4
Proposed Preliminary Model Input Database

	Horizontal Hydraulic Conductivity feet/day	**Vertical Hydraulic Conductivity** feet/day	**Effective Porosity** Percent
HSU A	400	40	3 to 15
	200	20	
	150	15	
	100	10	
	50	5	
	300	30	
HSU B	10	1	3 to 14
	30	3	
	20	2	
	15	1.5	
HSU D	10	1	8 to 22
	20	2	
	15	1.5	

HSU Hydrostratighic Unit
Range of proposed model input values based on Central Phoenix Plume Model (Weston, 2000)